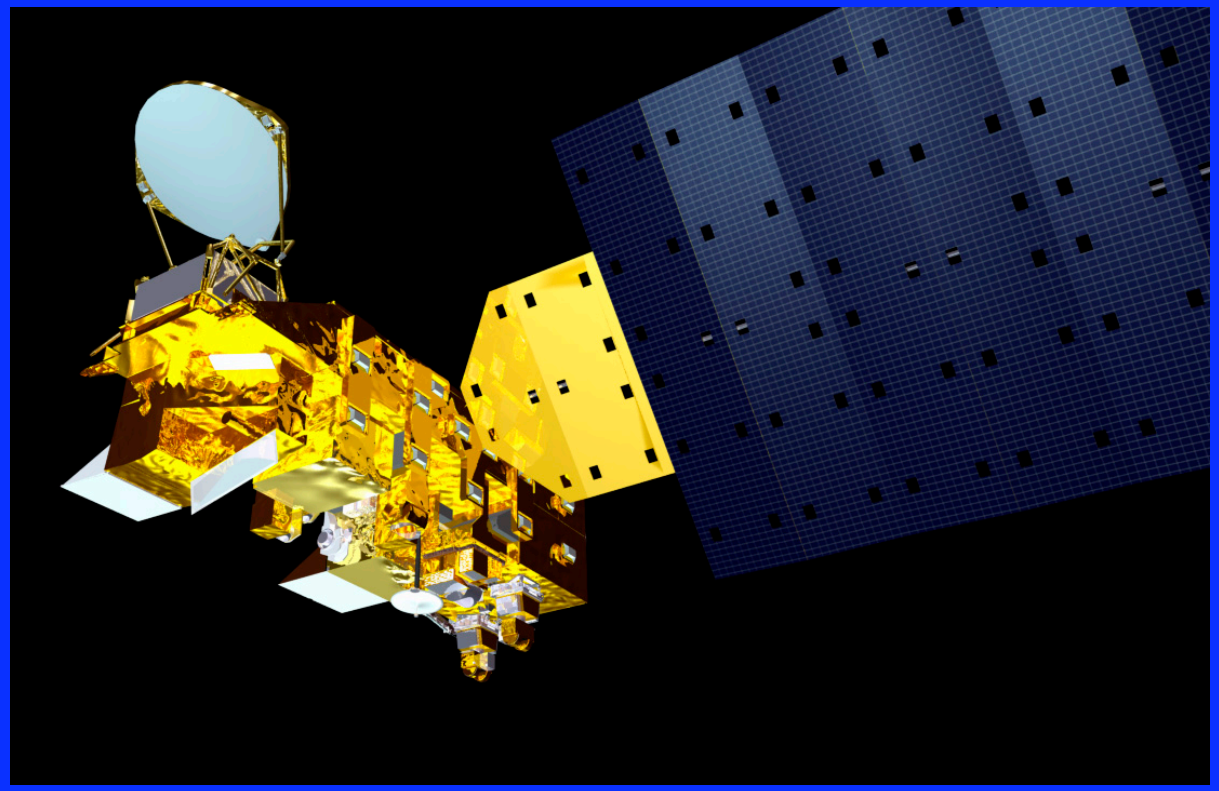
State of CERES



Norman G. Loeb, NASA LaRC

CERES Science Team Meeting September 13, 2010, Paris, France

NASA Earth Science

- NASA Administrator is Charles Bolden, Jr.
- AA for Space and Earth Science is Ed Weiler.
- Head of Earth Science is Mike Freilich.
- Jack Kaye is Associate Director for R&A.
- David Considine is NASA HQ Modeling lead and CERES Program Scientist.
- Hal Maring remains Radiation Sciences program lead.
- Steve Volz is the Earth Science Deputy for Missions.
- Richard Slonaker is Program Executive, NASA-HQ.

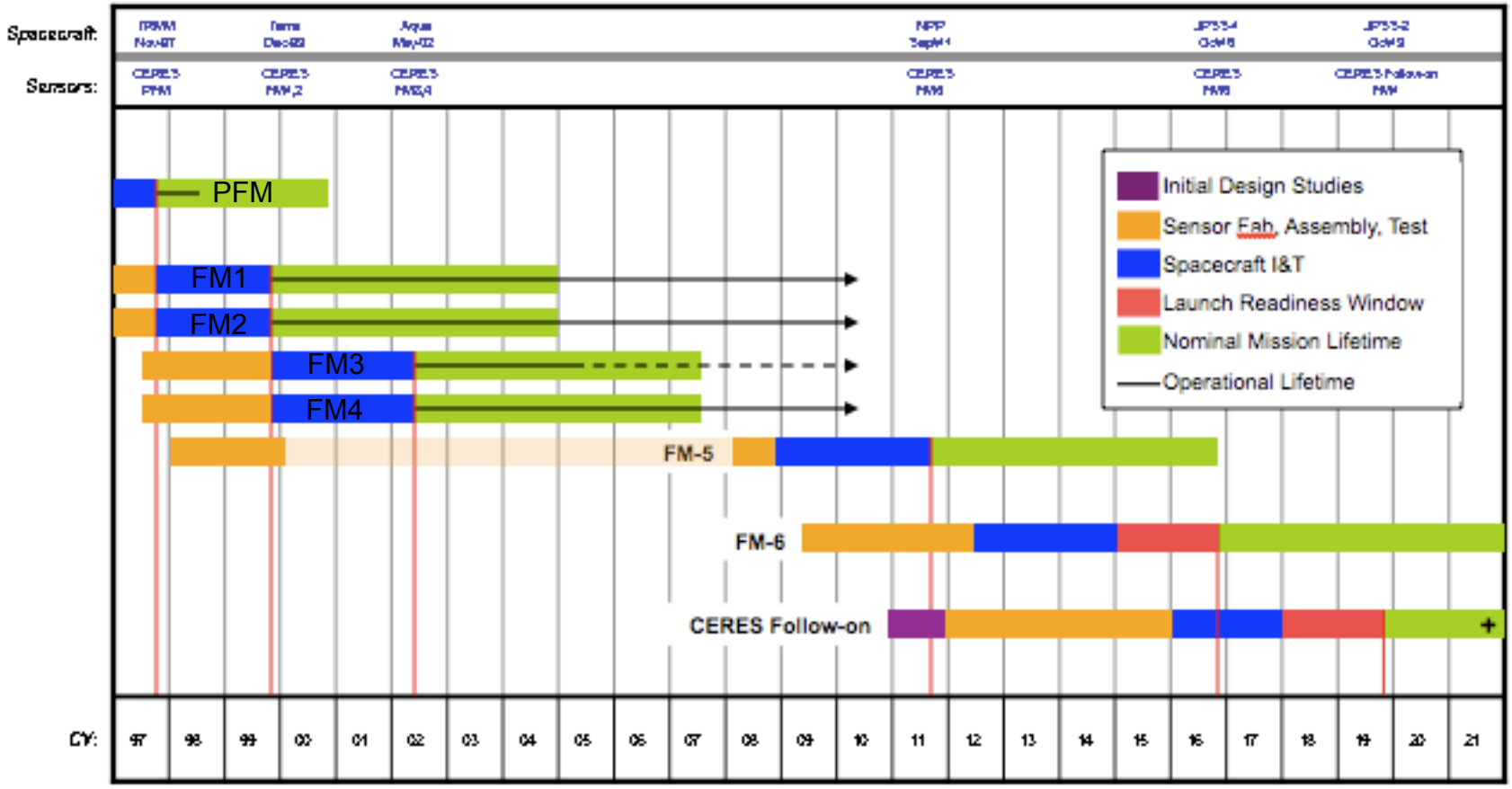
NASA Science Mission Directorate FY11 President's Budget Request

	FY09	FY10	FY11	FY12	FY13	FY14	FY15
Science	$4,903.1	$4,493.3	$5,005.6	$5,248.6	$5,509.6	$5,709.8	$5,814.0
Heliophysics *	$607.8	$627.4	$641.9	$647.6	$679.8	$704.4	$750.8
Astrophysics	$1,304.9	$1,103.9	$1,076.3	$1,109.3	$1,149.1	$1,158.7	$1,131.6
Planetary Science	$1,288.1	$1,341.3	$1,485.7	$1,547.2	$1,591.2	$1,630.1	$1,649.4
Earth Science	$1,702.3	$1,420.7	$1,801.7	$1,944.5	$2,089.5	$2,216.6	$2,282.2

- Increases across the board from FY10 to FY15. Earth Science increases by 60%.
- FY11 ES increases by $382 million over FY 2010 enacted, and $1.8 billion over 4-years (FY 2011-14) compared to the FY 2010 Budget;
- Re-flies the Orbiting Carbon Observatory, which is critical to our understanding of the Earth's carbon cycle and its effect on climate change;
- Accelerates the development of new satellites to enhance observations of the climate and other Earth systems;
- Expands and accelerates Venture-class competitive PI-led missions;
- Enhances climate change modeling capabilities to enhance forecasts of regional and other effects;
- Operates 15 Earth-observing spacecraft in orbit and launches Glory, NPP, and Aquarius;
- Proceeds toward completion and launch of remaining foundational missions: LDCM (6/13) and GPM (7/13).

CERES Flight Schedule

Enabling Climate Data Record Continuity



CERES Team Leads

- Principal Investigator: Norman Loeb
- Project Scientist: Kory Priestley

- CERES Working Groups:
- Instrument: Kory Priestley
- ERBElike: Takmeng Wong
- Clouds: Pat Minnis
- Inversion: Norman Loeb
- SOFA: David Kratz
- SARB: Tom Charlock
- TISA: David Doelling
- FLASHFlux: Paul Stackhouse & David Kratz
- Data Management: Jonathan Gleason
- ASDC: John Kusterer

CERES News

- "The Science of Terra and Aqua" NASA ROSES proposals (March 2010).
- AMS Radiation Conference (Joint with Cloud Physics):

- June 28–July 2, 2010. Portland OR.

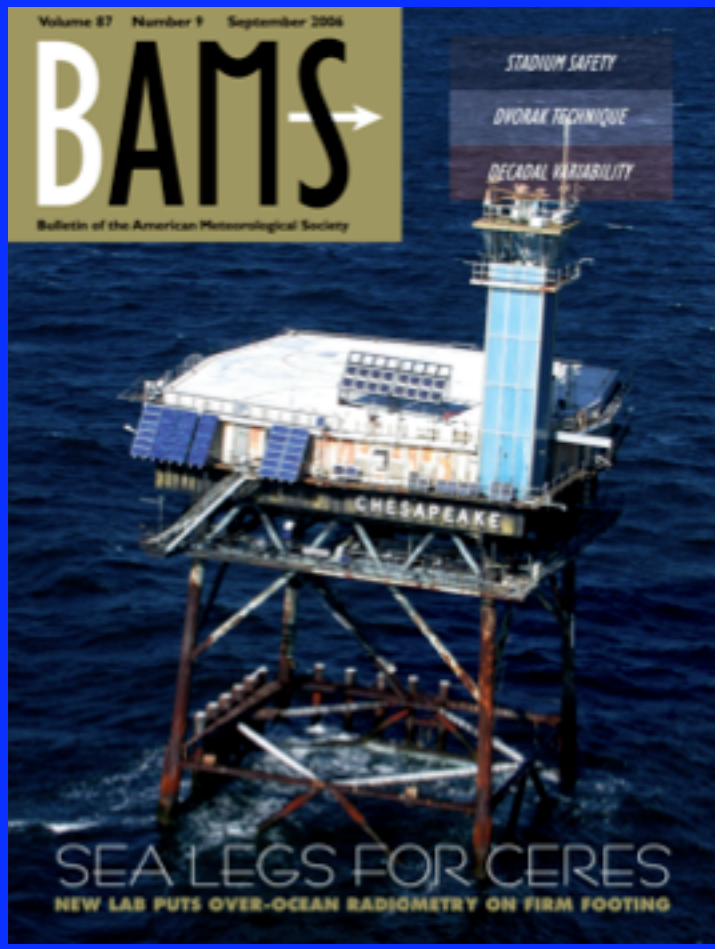
  -> ≈ 40 papers that use CERES (21% of AtRad Conf).

- Workshop on next generation Earth radiation budget observing requirements – NOAA NCDC in Asheville, NC 13-14 July.
- IGARSS Terra at 10 session. July 26-30. Honolulu, HI

CERES News

CERES Ocean Validation Experiment (COVE) Site:

- Operates instruments from BSRN, AERONET, MPL.
- US Coast Guard wants to excess or auction off the Chesapeake Light-house platform.
- State and local (VA Beach) govern-ments considering. VA Beach sent Coast Guard a letter of intent to take platform over. Not sure what they will use it for.
- If VA Beach changes it's mind, light-house will be auctioned off.



- Our goal is to continue observations regardless of who assumes responsibility for lighthouse.

Upcoming Conferences & Meetings of Interest

CERES Science Team Meeting:

- Fall 2010: Sept 13-16. Paris, France. CERES/ScaRaB/GERB/LMD

EUMETSAT Meteorological Satellite Conference:

- September 20-24, 2010. Cordoba, Spain.

SPIE Asia-Pacific Remote Sensing:

- October 11-14, 2010. Incheon, Republic of Korea.

PCMDI-NASA Meeting:

- CERES invited to contribute to CMIP5 and IPCC AR5 – Data Portal for Earth System Grid. Oct 12 meeting at Lawrence Livermore National Laboratory (LLNL).

A-Train Symposium:

- October 25-28, 2010. New Orleans, LA

Fall AGU:

- December 13-17, 2010. San Francisco, CA

Observing and Modelling Earth's Energy Flows:

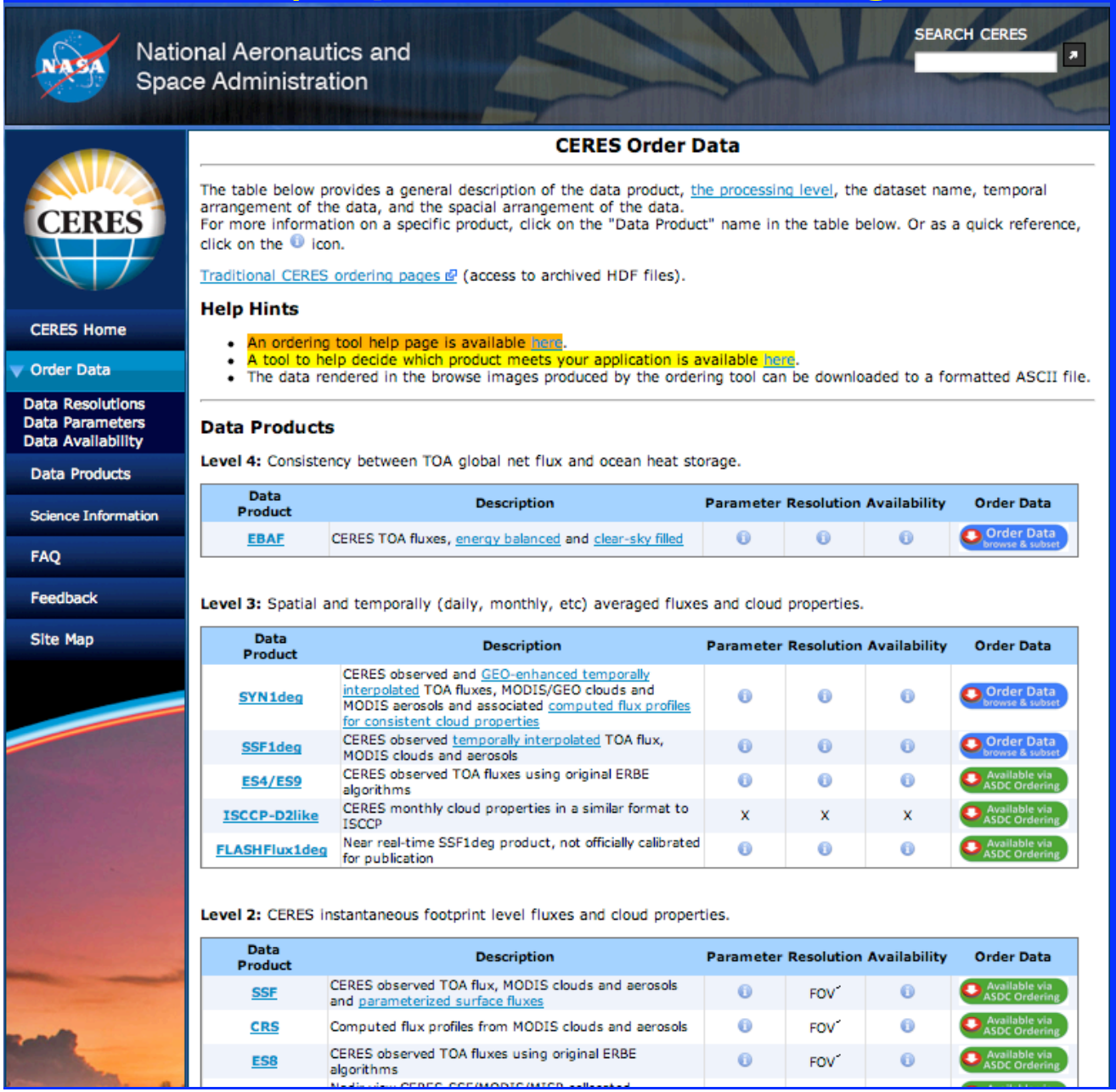
- 10-14 Jan 2011, ISSI, Bern, Switzerland (by Invitation)

AMS Annual Meeting

- 23-27 Jan 2011, Seattle, WA

CERES Webpage Redesign http://ceres.larc.nasa.gov/

New CERES L3 Data Subsetting/Visualization/Ordering Tool (http://ceres.larc.nasa.gov/order_data.php)

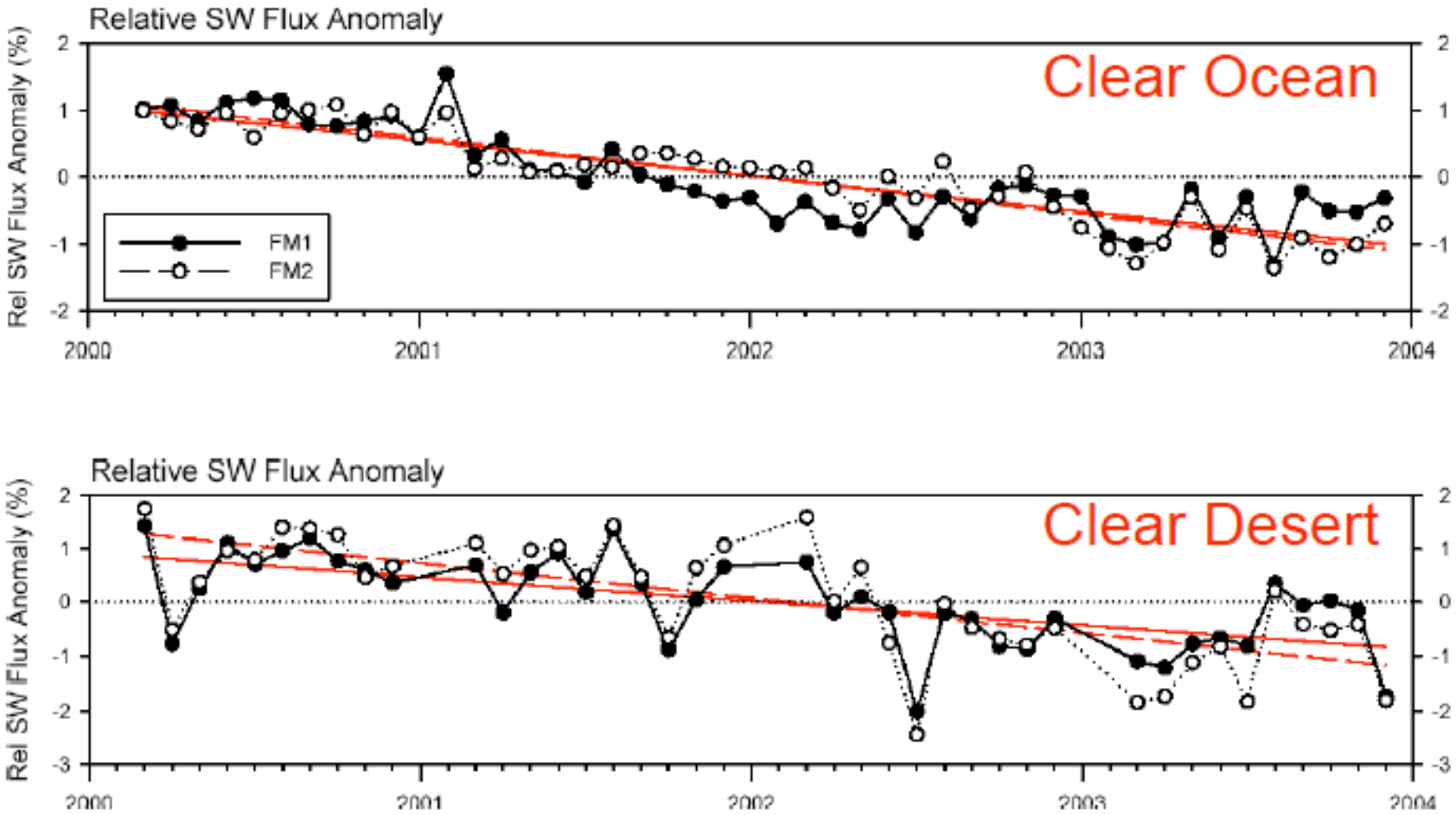


- Menu-driven, parameter based subsetting.
- Visualize data before ordering (regional, zonal and global plots, google-Earth enabled, create movies, etc.).
- Download data directly from site.
- Output in netCDF and ASCII.
- Improved documenta-tion.

CERES Terra/Aqua Edition3 Improvements

- CERES Instrument group have completed Edition3 gains and time-varying spectral response function changes for 10 years of Terra and 7 years of Aqua measurements !!!!!!
  - This work has been 5 years in the making. Countless brainstorming sessions, strategy meetings, starts-and-stops, etc.
  - Credit goes to: Kory Priestley, Susan Thomas, Nitchie Manalo-Smith, Dale Walikainen, Mohan Shankar, Peter Szewczyk, Phil Hess, Denise Cooper, Robert Wilson and Grant Matthews.

CERES SSF SW TOA Flux Anomaly



Discovery of spectral darkening problem in November 2004.

Edition2_Rev1 SW Scaling Factors

A table of Rev1 adjustment factors is issued via the quality summary, authors then use the description "Edition2_Rev1"

ATMOSPHERIC SCIENCES DATA CENTER

CERES Terra Revision Table

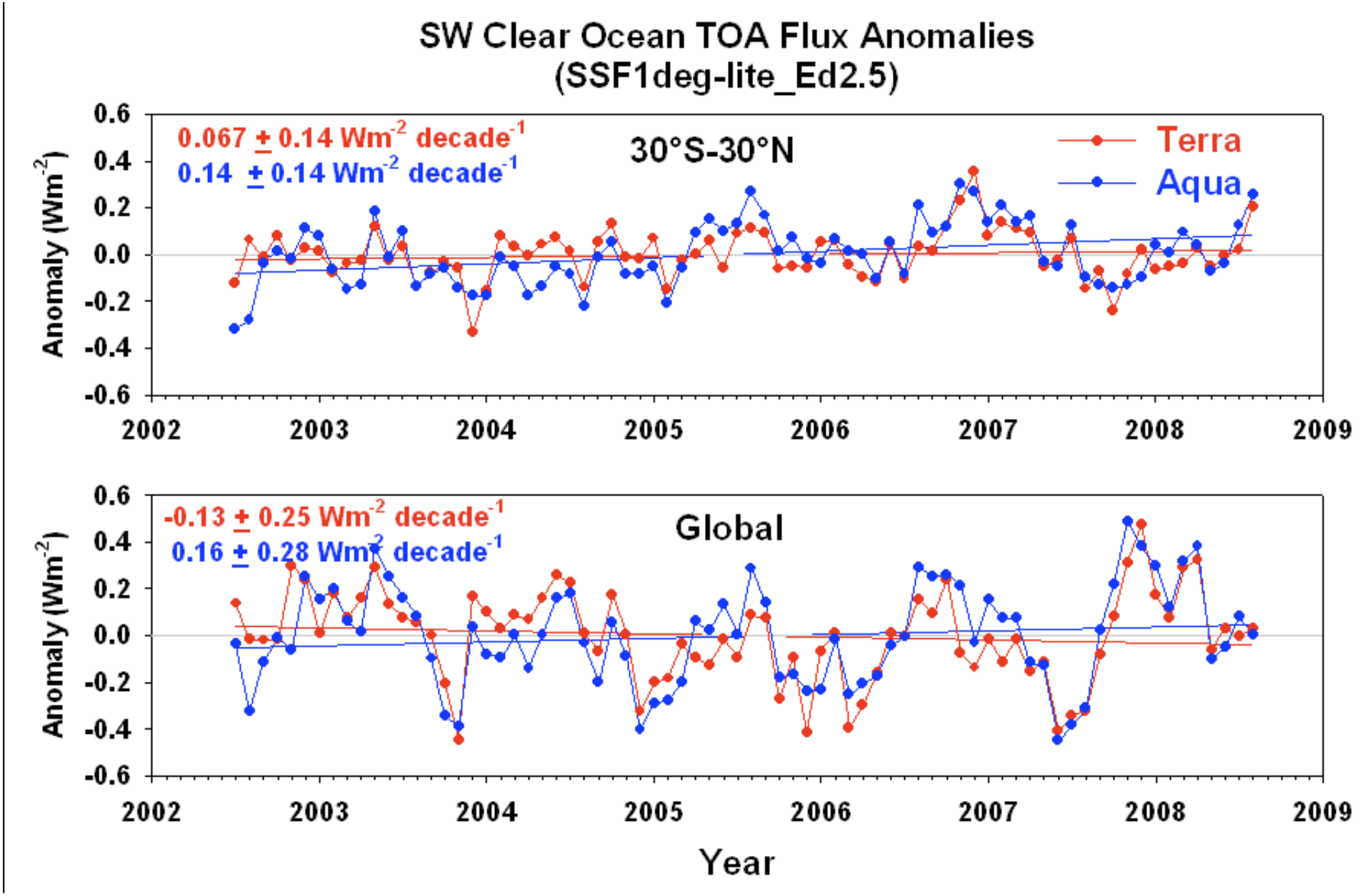
2000 | 2001 | 2002 | 2003 | 2004 | Tab-delimited file

		All Sky		Clear Ocean	
Year	Month	FM1	FM2	FM1	FM2
2003	Jan	1.011	1.015	1.012	1.017
	Feb	1.011	1.015	1.012	1.018
	Mar	1.011	1.015	1.012	1.019
	Apr	1.011	1.014	1.012	1.019
	May	1.011	1.015	1.012	1.020

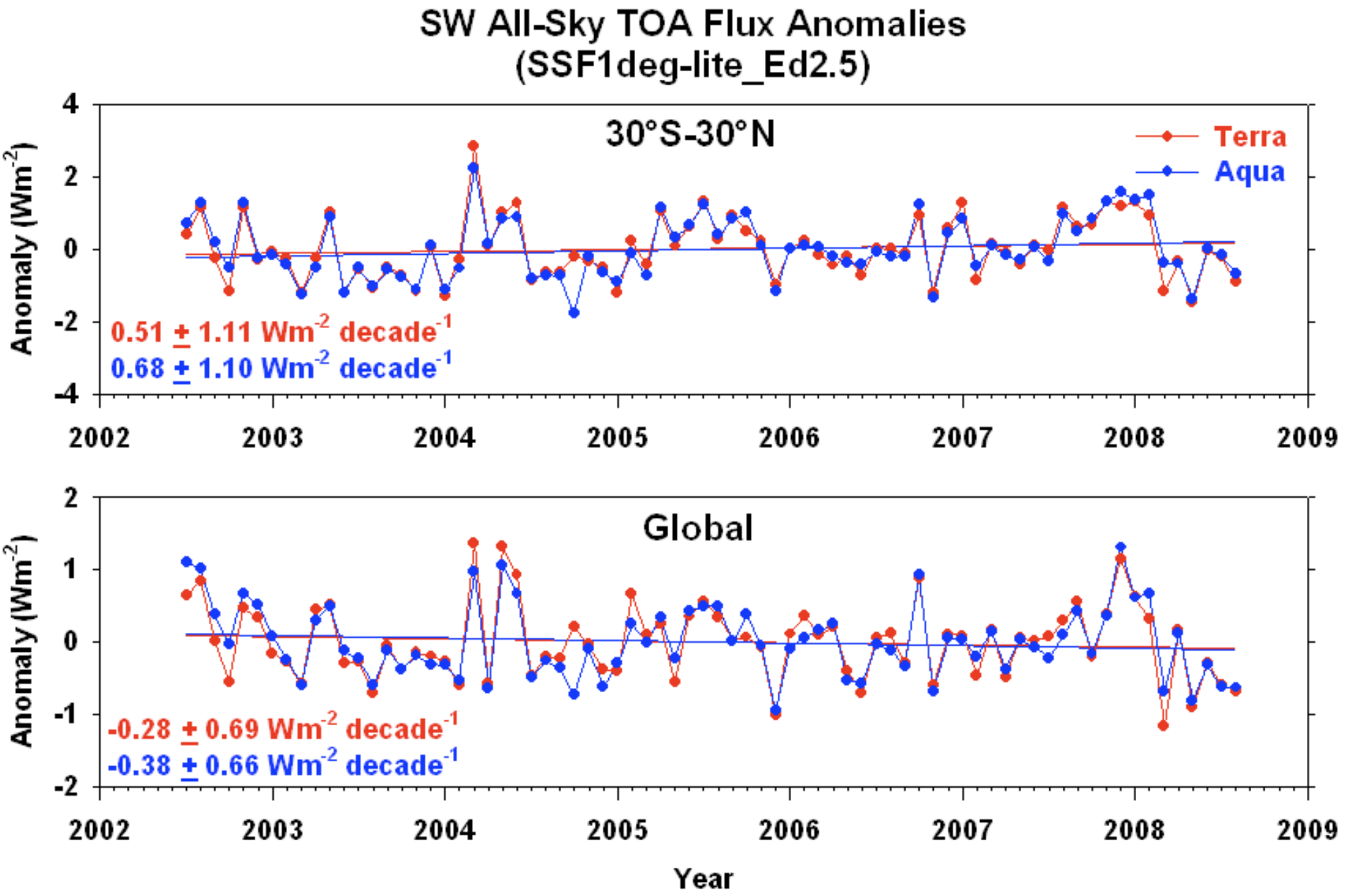
Multiply your May 03 Terra allsky SW fluxes by these values

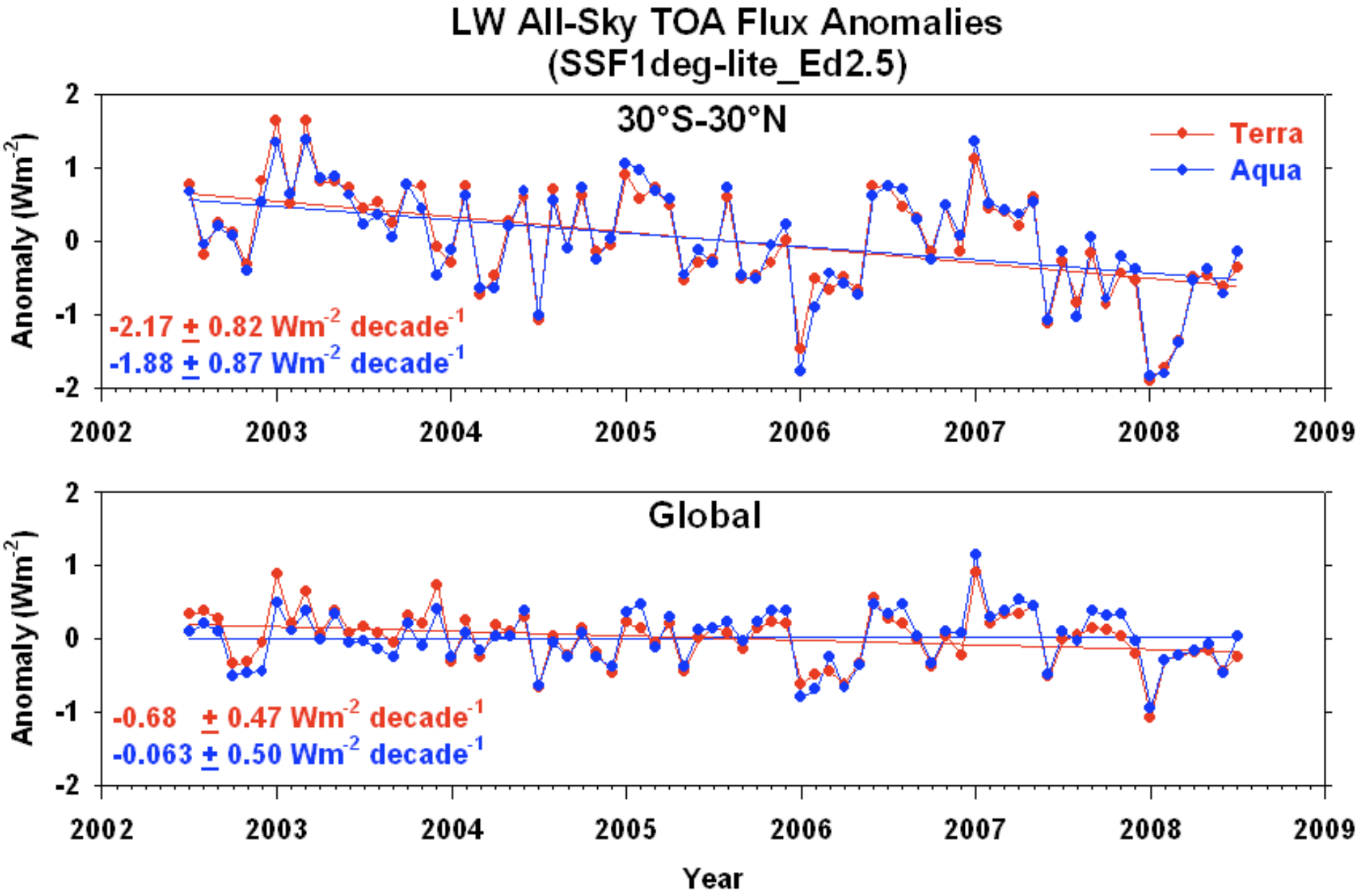
Multiply your May 03 Terra clear ocean SW fluxes by these values

Introduction of user-applied rev1 corrections in May 2005.

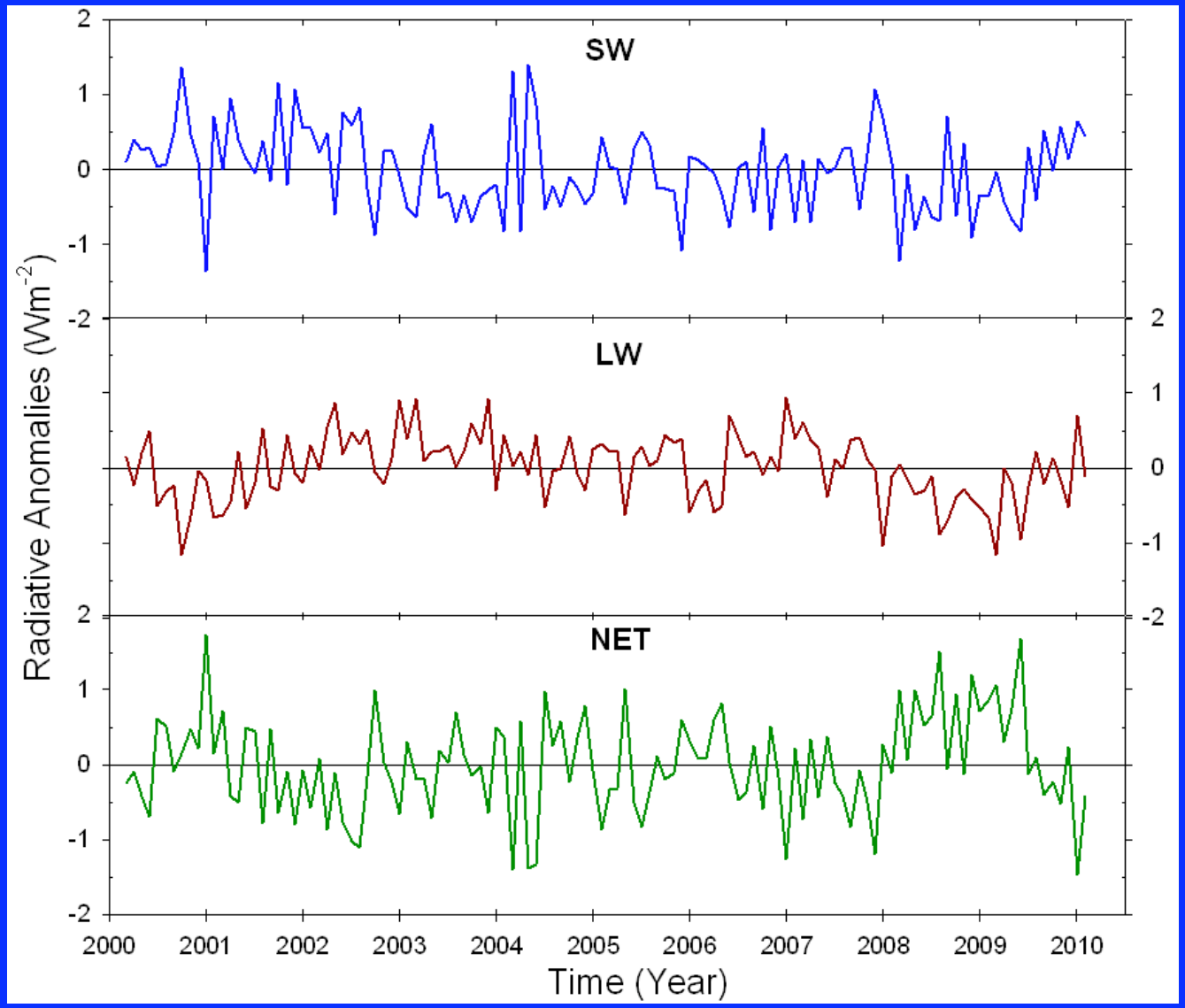


Edition3 Instrument Improvements (September 2010).

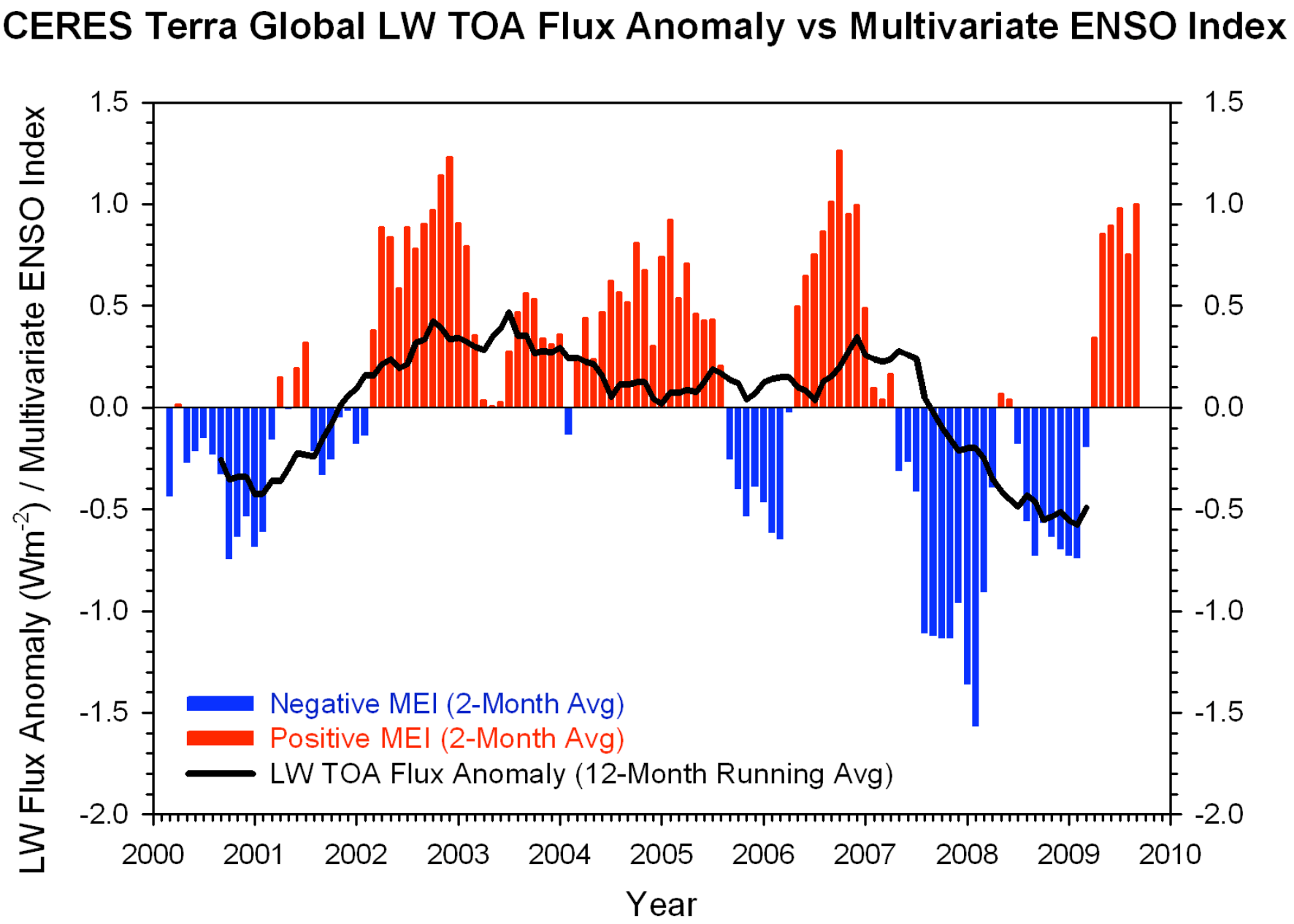

SW All-Sky TOA Flux Anomalies
(SSF1deg-lite_Ed2.5)
30°S-30°N
Terra
Aqua
Anomaly (Wm-2)
0.51 ± 1.11 Wm-2 decade-1
0.68 ± 1.10 Wm-2 decade-1
Global
-0.28 ± 0.69 Wm-2 decade-1
-0.38 ± 0.66 Wm-2 decade-1
2002
2003
2004
2005
2006
2007
2008
2009
Year


LW All-Sky TOA Flux Anomalies
(SSF1deg-lite_Ed2.5)
30°S-30°N
Terra
Aqua
-2.17 ± 0.82 Wm-2 decade-1
-1.88 ± 0.87 Wm-2 decade-1
Anomaly (Wm-2)
2
1
0
-1
-2
2002
2003
2004
2005
2006
2007
2008
2009
Global
-0.68 ± 0.47 Wm-2 decade-1
-0.063 ± 0.50 Wm-2 decade-1
Year

A Decade of Global CERES Top-of-Atmosphere Radiation Anomalies (CERES SSF1deg-lite_Ed2.5)

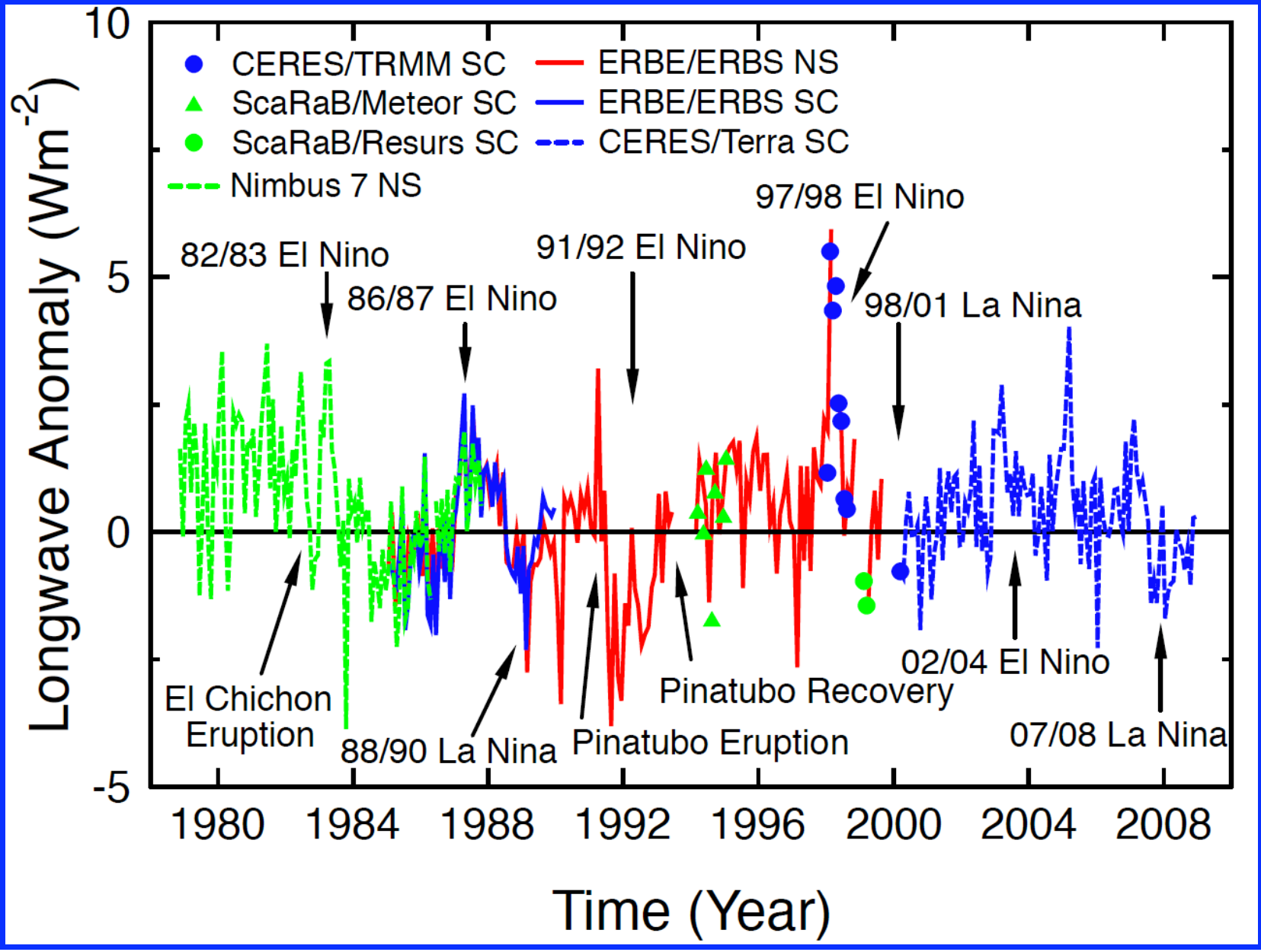


CERES is providing the first decadal global climate data record of the Earth's Radiation Budget at climate accuracy from broadband instruments.


CERES Terra Global LW TOA Flux Anomaly vs Multivariate ENSO Index
LW Flux Anomaly (Wm-2) / Multivariate ENSO Index
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Negative MEI (2-Month Avg)
Positive MEI (2-Month Avg)
LW TOA Flux Anomaly (12-Month Running Avg)

32-years of Radiation Measurements

(LW Anomaly; 20°S-20°N)



CERES Terra/Aqua Edition2.5 Lite Data Products

Motivation: To get instrument calibration improvements into CERES level-3 (gridded monthly) data products ASAP.

- Delivery and processing of full-suite of level-2 and 3 algorithm improvements will much more time.
- How can new calibration improvements make their way into L3 data products now?

The CERES Edition2.5 "Lite" products:

-> Uses best-quality Edition3 instrument radiances and existing Ed2 cloud properties to generate L3 TOA fluxes as quickly as possible.

-> Will consist of a small subset of SRBAVG cloud and TOA radiation parameters.

-> Accompanied by a new prototype subsetter/visualization/ ordering tool.

-> Currently ready to release gridded daily and monthly SSF1deg-lite_Ed2.5, SYN1deg-lite_Ed2.5 and EBAF Ed2.5.

Parameter List in CERES "Lite" Data Products

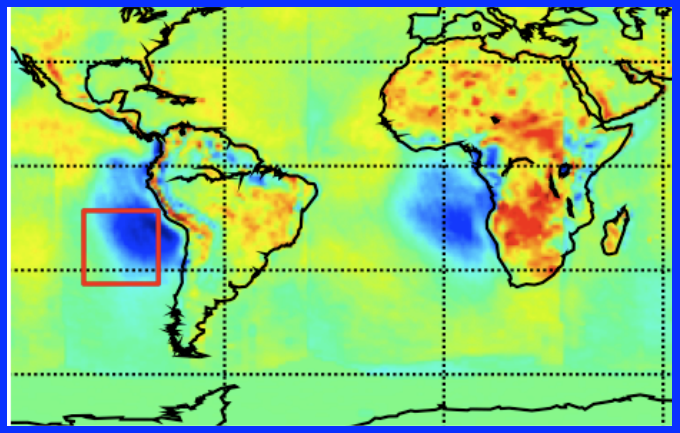
Parameters			CLR	ALL
	TOA Fluxes	Shortwave Flux	☐	☐
		Longwave Flux	☐	☐
		Window-region Flux	☐	☐
		Net Flux	☐	☐
		Albedo	☐	☐
		Solar Insolation Flux	N/A	☐
		Number of Observations of TOA SW Flux	☐	☐
		Number of Observations of TOA LW Flux	☐	☐
			DAY	DAY–NIGHT
	Cloud Parameters	Cloud Area Fraction	☐	☐
		Cloud Effective Pressure	☐	☐
		Cloud Effective Temperature	☐	☐
		Cloud Particle Phase	☐	☐
		Liquid Water Path	☐	☐
		Ice Water Path	☐	☐
		Water Particle Radius	☐	☐
		Ice Particle Effective Diameter	☐	☐
		Cloud Visible Optical Depth	☐	☐
	Auxiliary Data	Snow/Ice Percent Coverage		
		Ocean Fraction Coverage		
		Total Aerosol Visible Optical Depth @ 0.55 microns		
		Total Aerosol Visible Optical Depth @ 0.55 microns - Fine Mode		
		Total Aerosol Visible Optical Depth Percent @ 0.55 microns		
		Wind Speed		
		Skin Temperature		
		Precipitable Water		

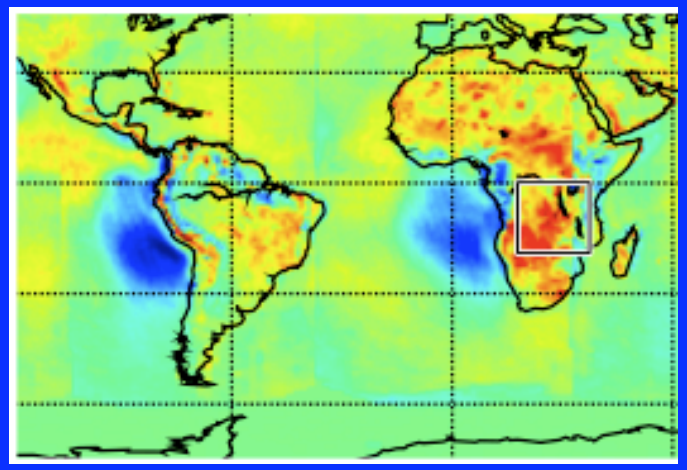
SYN1deg-lite_Ed2.5
-> Similar to SRBAVG GEO

SSF1deg-lite_Ed2.5
=> Similar to SRBAVG nonGEO

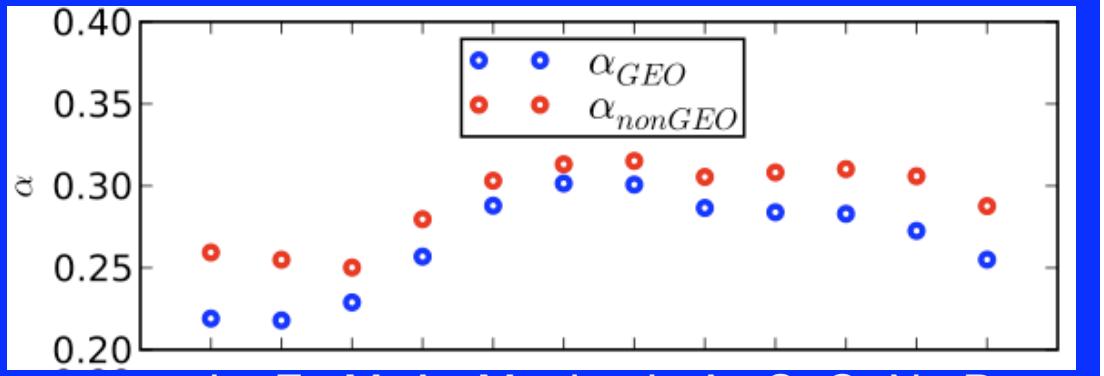
- **Daytime-only and day/night average cloud properties.**
- **Time-varying TOA solar irradiance from SORCE.**

Does Diurnal Cycle of Radiation Matter?
Annual Cycle of Albedo for Marine Stratus and Land Convection from 8 Years of CERES Terra

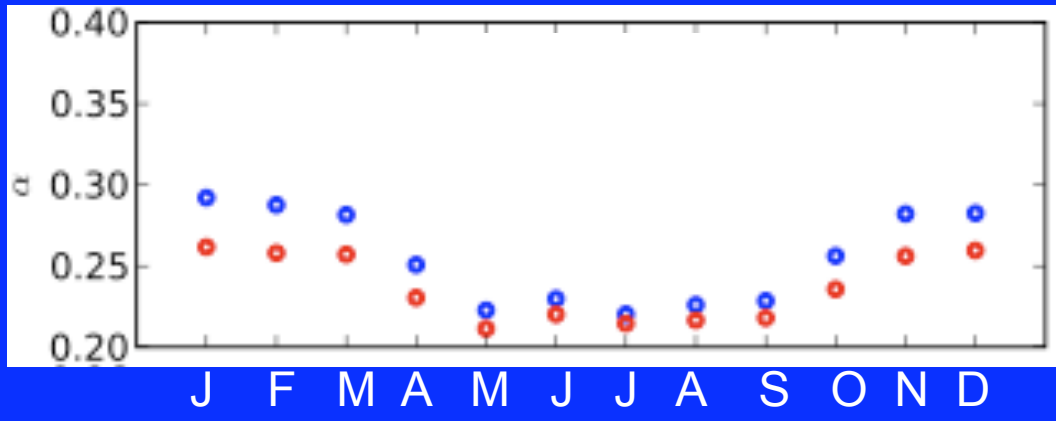




Marine Stratus Albedo

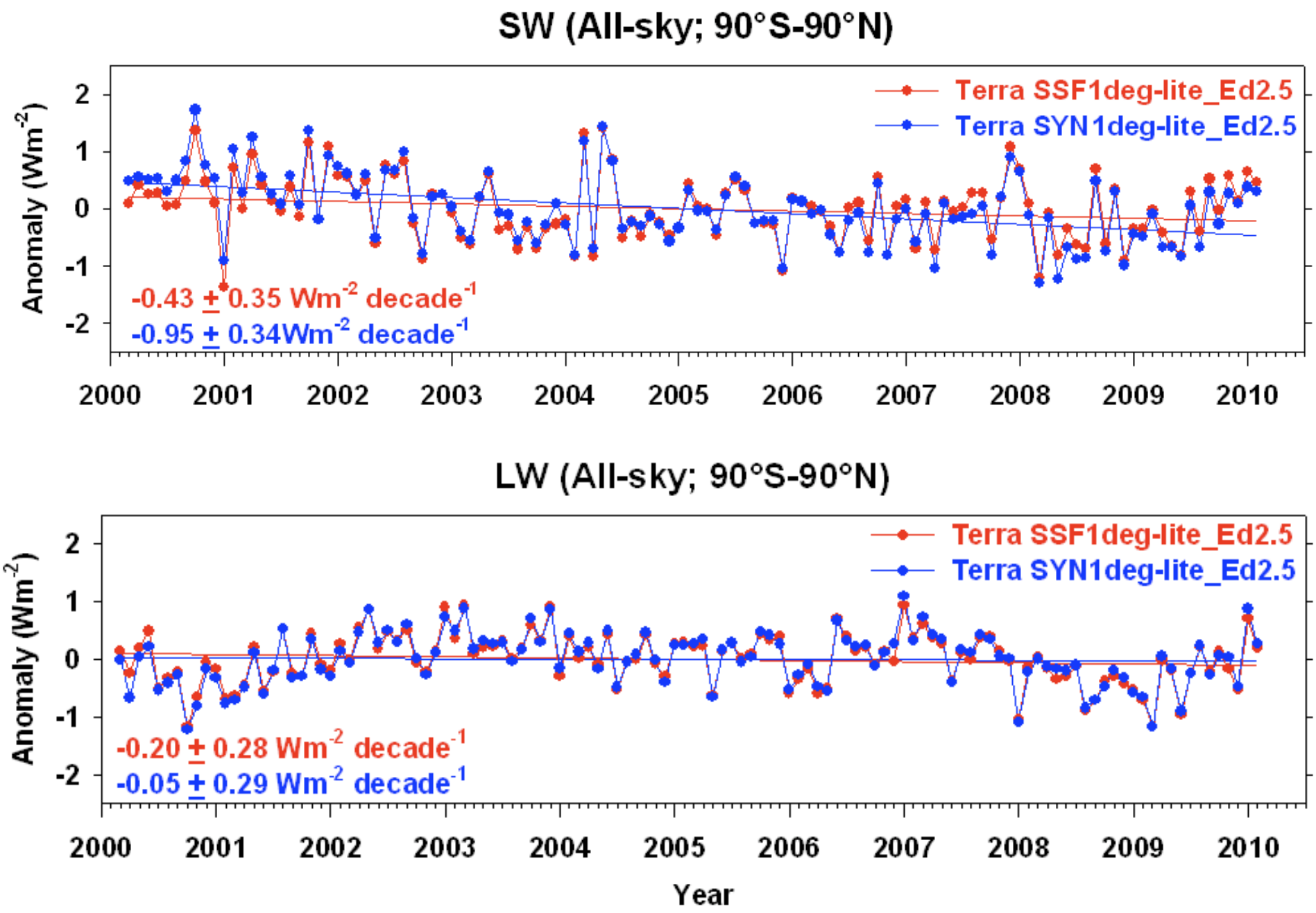


Convective Cloud Albedo

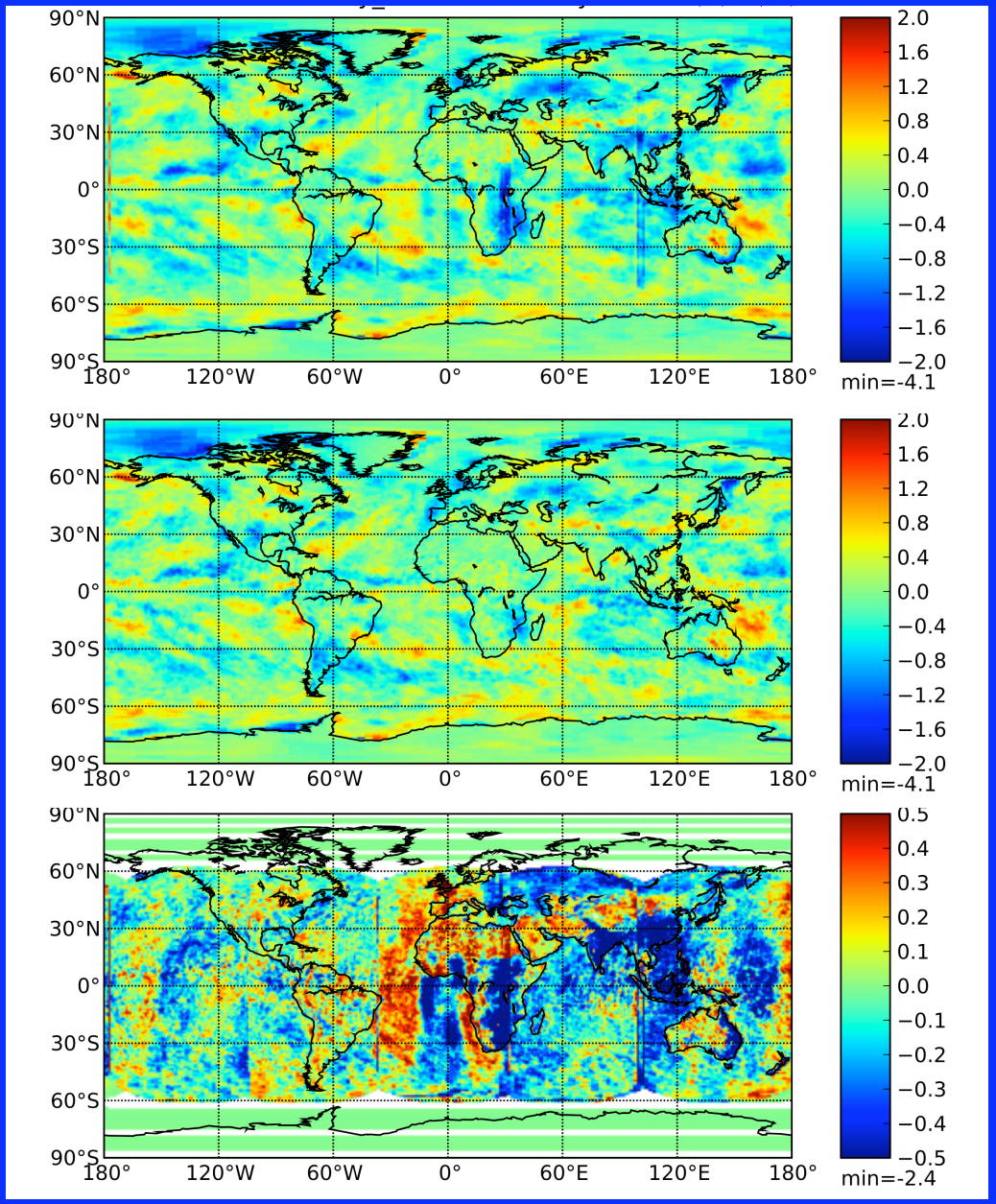


- Diurnal variations in marine stratus and convective clouds have a strong influence on the amplitude of the annual cycle of albedo for these cloud types.
- Merging CERES Terra with geostationary satellite observations captures changes in both diurnal and annual cycles of albedo.

CERES Terra/Aqua Edition2.5 Lite Data Products



10-year Regional Trends (Wm^{-2} per decade)



SYN1deg-lite_Ed2.5 (GEO)

SFF1deg-lite_Ed2.5 (non-GEO)

SYN1deg minus SSF1deg

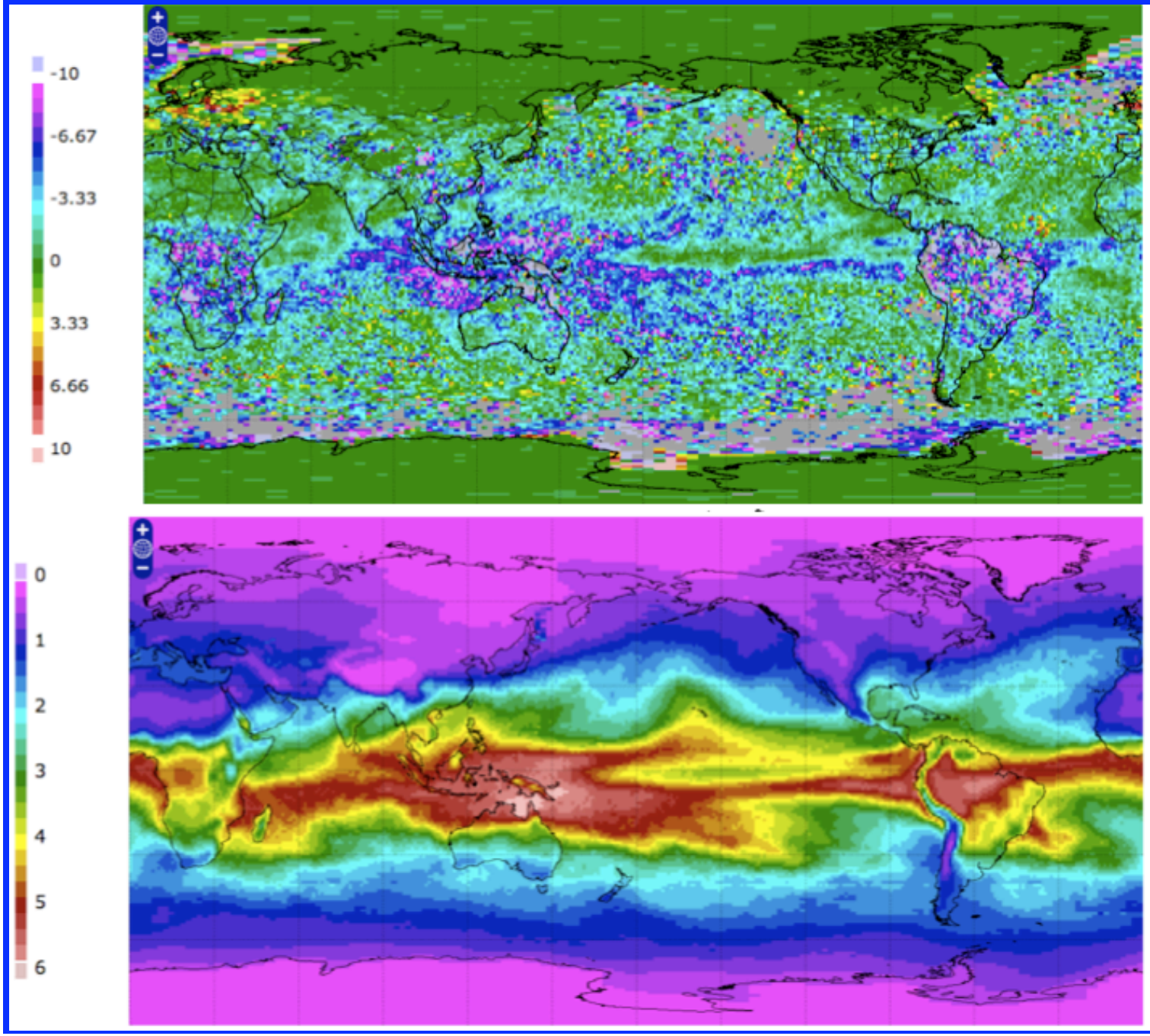
Energy Balanced and Filled (EBAF) Ed2.5A

- **All-sky TOA Fluxes: Adjust SW and LW TOA fluxes in SYN1deg-lite_Ed2.5 within their range of uncertainty to remove the inconsistency between average global net TOA flux and estimated heat storage in the Earth-atmosphere system.**
- **Clear-sky TOA Fluxes: Uses CERES+MODIS clear-sky fluxes to "fill in gaps" in standard CERES clear-sky TOA flux products.**

Table 2: Comparison of adjusted ERBE, CERES SRBAVG-GEO and CERES EBAF TOA fluxes.

	ERBE Adj (Trenberth1997) (02/85-04/89)	CERES SRBAVG-GEO-Ed2D_rev1 (03/00-02/05)	CERES EBAF Edition1A (Loeb et al., 2009) (03/00-02/05)	CERES SYN1deg Terra Edition2.5A (03/00-02/10)	CERES EBAF Edition 2.5A (03/00-02/10)
Solar Irradiance	341.3	341.3	340.0	340.1	340.1
LW (All-Sky)	234.4	237.1	239.6	238.8	239.6
SW (All-Sky)	106.9	97.7	99.5	97.7	99.5
Net (All-Sky)	0.0	6.5	0.90	3.6	1
LW (Clear-Sky)	264.9	264.1	269.5	267.6	266
SW (Clear-Sky)	53.6	51.1	52.5	50.1	52.4
Net (Clear-Sky)	22.8	26.2	18.1	22.4	21.7
LW CRE	30.5	27.0	29.9	28.8	26.4
SW CRE	-53.3	-46.6	-47.1	-47.6	-47.1
Net CRE	-22.8	-19.7	-17.2	-18.8	-20.7

High-Resolution vs Coarse-Resolution Clear-Sky LW TOA Flux



CERES/ MODIS minus CERES clear-sky LW TOA flux (Wm^{-2})

Precipitable Water (mm)

Re-Prioritization of CERES Edition3 Data Products

- **Currently running Edition2 for all subsystems. Ed2.5 Lite data products only include small subset of CERES parameters.**
- **Instrument running both Editions 2 and 3 BDS/IES products.**
- **Getting the full-suite of Level 1 through 3 planned Edition3 algorithm improvements has been slow:**
- Discovery of spectral darkening of SW channel (Instrument).
- Clouds waiting for CALIPSO/Cloudsat validation.
- MTSAT problem (TISA).
- Production code migration effort from SGI -> IBM Linux cluster environment.
- SAN failure in August 2008: loss of 6-8 months for some working groups.
- Feb 2010: Unplanned power outage and subsequent LUN thrashing issue.
- New scripting requirement for deliveries to AMI, our new production environment.
- Re-architecting of AMI in August 2010.
- Production on AMI has not started yet: ~1.5 years behind schedule.

Alternate Edition3 Strategy

- Produce a scaled-down version of Edition3 that includes only a subset of the algorithm improvements proposed in the 2009 Senior Review that can be processed now on the older SGI (Warlock), P4 (Magneto) and available P6, X86 (AMI-P) systems.
- Edition3 Algorithm improvements: Instrument calibration and spectral characterization. SOFA surface fluxes. Updated polar and ANN ADMs, merged Terra+Aqua+GEO.
- Utilize existing inputs that are “ready-to-go” now (MOA, MODIS, GGEO, MATCH, etc.).
- Process only crosstrack instrument for Level-2 and -3 data products.
- All other algorithm/input file improvements (e.g., Clouds, ADMs, SARB, TISA) included in Edition4 and run on AMI or AMI-P.

Pros and Cons of New Edition3 Strategy

Pros:

- Provides full-suite of CERES data products with instrument calibration improvements in shortest time.
- Will supersede "lite" data products planned for subsetter.
- Gets merged Terra+Aqua SYN1deg out sooner.
- Edition4 will have consistent Clouds and ADMs.
- Provides more time for Clouds Edition4 delivery (July 25 to October 15, 2010).
- Risk mitigation: new cloud algorithm on new platform.
- Provides more time for TISA Edition4 delivery (date TBD).
- Baby-step to Edition4 likely increase chance of Edition4 getting through more smoothly.

Cons:

- Delays processing Edition3 ERBE-like until after Senior Review.
- Delays release of cloud algorithm improvements as "Edition" version.
- Some data products will not be produced as Edition3 due to limited computational resources (e.g., CRS, FSW).
- New parameters added to CERES data products (e.g., SSF) delayed.

Terra and Aqua Senior Review - 2011

- Likely due March 2011.
- Will need science team input on submitted, in-press and published journal articles.
- Will summarize accomplishments during past 2 years and goals for next 4 years.
- Determines CERES budget for next 2 years.

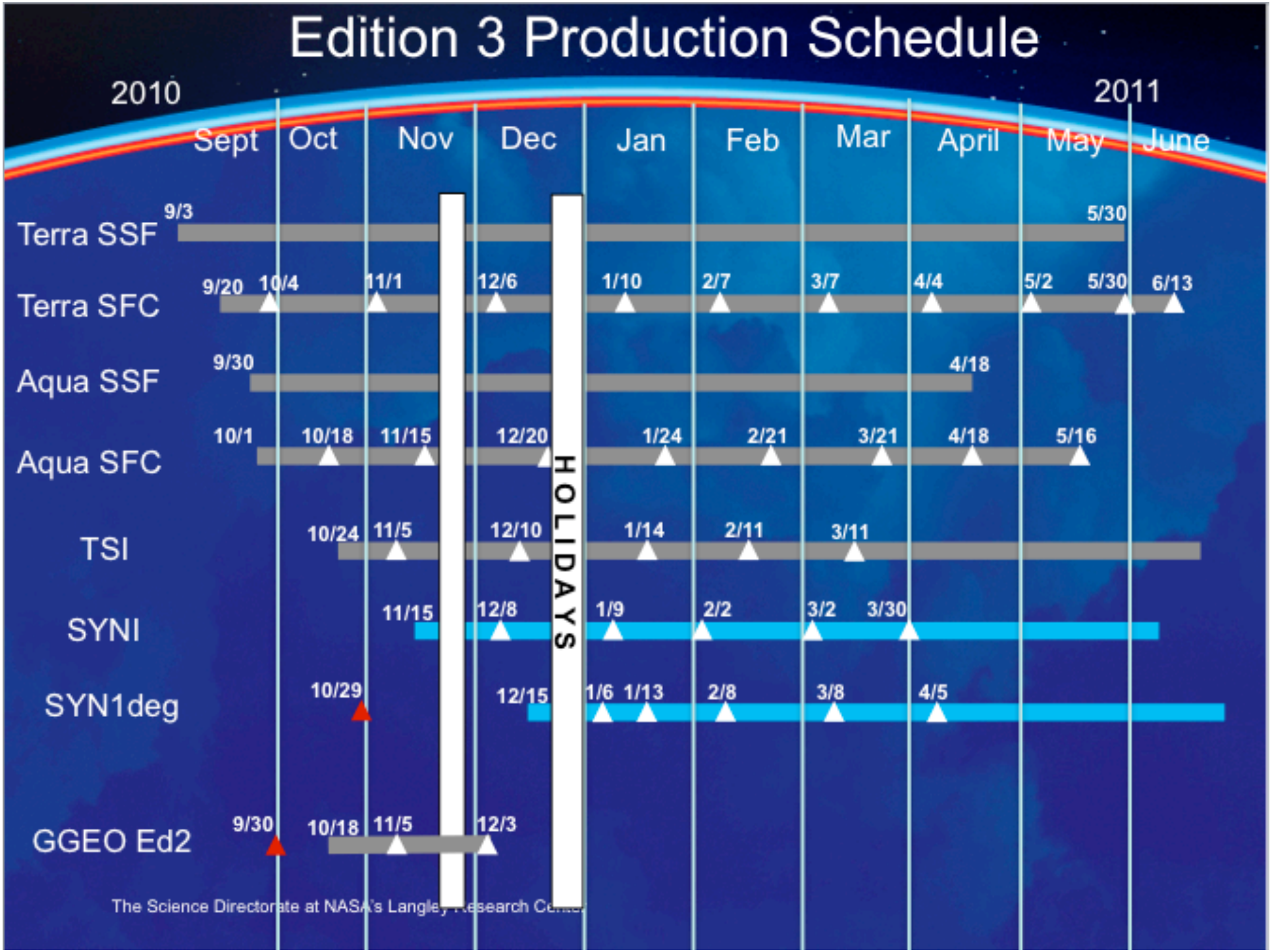
Objectives for 2011 Senior Review

i) 10-years of Terra CERES_SSF1deg_Ed3 monthly,daily

ii) 8-years of Aqua CERES_SSF1deg_Ed3 monthly,daily

iii) 5-years of Edition3 merged Terra+Aqua SYN1deg_Ed3

iv) Final delivery of Edition4 Clouds with all algorithm improvements previously due for delivery July 25, 2010 (new deadline: October 15).


Edition 3 Production Schedule
2010
2011
Sept
Oct
Nov
Dec
Jan
Feb
Mar
April
May
June
Terra SSF
9/3
5/30
Terra SFC
9/20
10/4
11/1
12/6
1/10
2/7
3/7
4/4
5/2
5/30
6/13
Aqua SSF
9/30
4/18
Aqua SFC
10/1
10/18
11/15
12/20
1/24
2/21
3/21
4/18
5/16
TSI
10/24
11/5
12/10
1/14
2/11
3/11
SYNI
11/15
12/8
1/9
2/2
3/2
3/30
SYN1deg
10/29
12/15
1/6
1/13
2/8
3/8
4/5
GGEO Ed2
9/30
10/18
11/5
12/3
HOLIDAYS
The Science Directorate at NASA's Langley Research Center

CERES FM5 on NPP Update.

- Comprised of 5 instruments:
  - Visible/Infrared Imager/Radiometer Suite (VIIRS)
  - Cross-track Infrared Sounder (CrIS)
  - Clouds and the Earth's Radiant Energy System (CERES)
  - Ozone Mapping Profiler Suite (OMPS)
  - Advanced Technology Microwave Sounder (ATMS)
- Status:
  - CERES, ATMS, OMPS, VIIRS on NPP spacecraft. CrIS was shipped June 17 and integrated on spacecraft in July.
- Official launch date: October 2011
- Significant concern over readiness of ground system.

CERES FM6 on NPOESS C1

- CERES FM6 is a government-furnished sensor manufactured by Northrop Grumman (NG), and provided to the JPSS program by NOAA/NASA.
- Northrop Grumman Aerospace System (NGAS) working under contract to NASA LaRC.
- Build-to-Print and from spare parts.
- Minor modifications needed to accommodate JPSS spacecraft interface and improve calibration.
- Start Date: May 2009; Delivery Date: July 2012; Launch in 2014.
- Successfully complete delta Preliminary Design Review in January 20, 2010.
- Received NOAA's FM6 Level-1 Requirements July 1.
- NASA preparing response to NOAA L1 Requirements.
- Delta Critical Design Review to be held September 28, 2010.

A-Train Update

- PARASOL started drifting away from A-Train in early Jan 2009 due to insufficient fuel needed to maintain A-Train orbit.
- Glory launch expected November 22, 2010.
- Japanese GCOM-W may join A-Train in 2012 with successor to AMSR-E instrument.
- CALIPSO passed 1000 day-mark in orbit on January 23, 2009. Successfully transitioned to backup laser on March 9, 2009. Has released Version 3 data products from ASDC.
- New merged CALIPSO-CloudSat-CERES-MODIS (C3M) dataset: 1 year (Jul06-Jun07) has been processed. Plan to process seasonal months in 2008 next (see S. Kato Co-I presentation).
- **A-Train Symposium:** October 25-28, 2010. New Orleans, LA

Decadal Survey

- NASA still committed to implementing DS. Tier 1 Missions:
  - Climate Absolute Radiance and Refractivity Observatory (CLARREO)
  - Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI)
  - Soil Moisture Active-Passive (SMAP)
  - Ice, Cloud, and Land Elevation Satellite (ICESat-II)

End